

CONSIDERATIONS FOR FABRICATORS

AEOS: HIGH STRENGTH STEEL

March 24, 2022

NUCOR[®]



Designation: A913/A913M – 07

Standard Specification for High-Strength Low-Alloy Steel Shapes of Structural Quality, Produced by Quenching and Self-Tempering Process (QST)¹

This standard is issued under the fixed designation A913/A913M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

1. Scope*

1.1 This specification covers high-strength low-alloy structural steel shapes in Grades 50 [345], 60 [415], 65 [450] and 70 [485], produced by the quenching and self-tempering process (QST).² The shapes are intended for riveted, bolted or welded construction of bridges, buildings and other structures.

1.2 The QST process consists of in line heat treatment and cooling rate controls which result in mechanical properties in the finished condition that are equivalent to those attained using heat treating processes which entail reheating after rolling. A description of the QST process is given in Appendix X1.

1.3 Due to the inherent characteristics of the QST process, the shapes shall not be formed and post weld heat treated at temperatures exceeding 1100°F [600°C].

1.4 When the steel is to be welded, it is presupposed that a welding procedure suitable for the grade of steel and intended use or service will be utilized. See Appendix X3 of Specification A6/A6M for information on weldability.

1.5 The values stated in either inch-pound units or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with this specification.

¹ This specification is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.02 on Structural Steel for Bridges, Buildings, Rolling Stock and Ships.

Current edition approved Nov. 1, 2007. Published November 2007. Originally approved in 1993. Last previous edition approved in 2004 as A913/A913M – 04. DOI: 10.1520/A0913_A0913M-07.

² The quenching and self-tempering process (QST) and the used apparatus are covered by patents held by the Centre de Recherches Métallurgiques (CRM)—Rue Ernest Solvay, 11, B4000, Liège (Belgium). Interested parties are invited to submit information regarding the identification of acceptable alternatives to these patented items to the Committee on Standards, ASTM Headquarters, 100 Barr Harbor Drive, West Conshohocken, PA 19380-2959. Comments will receive careful consideration at the meeting of the responsible technical committee, which any interested party

2. Referenced Documents

2.1 ASTM Standards:³

- A6/A6M Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling
- A673/A673M Specification for Sampling Procedure for Impact Testing of Structural Steel
- A898/A898M Specification for Straight Beam Ultrasonic Examination of Rolled Steel Structural Shapes

3. General Requirements for Delivery

3.1 Material furnished under this specification shall conform to the applicable requirements of the current edition of Specification A6/A6M.

4. Materials and Manufacture

4.1 The shapes shall be produced by the quenching and self-tempering process (QST). Self-tempering temperature shall be a minimum of 1100°F [600°C] and the self-tempering temperature for the material represented shall be reported on the mill test report. See Appendix X1 for Process Description.

4.2 For grades 60 [415], 65 [450], and 70 [485], the requirements for fine austenitic grain size in Specification A6/A6M shall be met.

5. Chemical Composition

5.1 The chemical analysis of the heat shall conform to the requirements prescribed in Table 1.

5.2 The steel shall conform on product analysis to the requirements prescribed in Table 1 subject to the product analysis tolerances in Specification A6/A6M.

6. Mechanical Properties

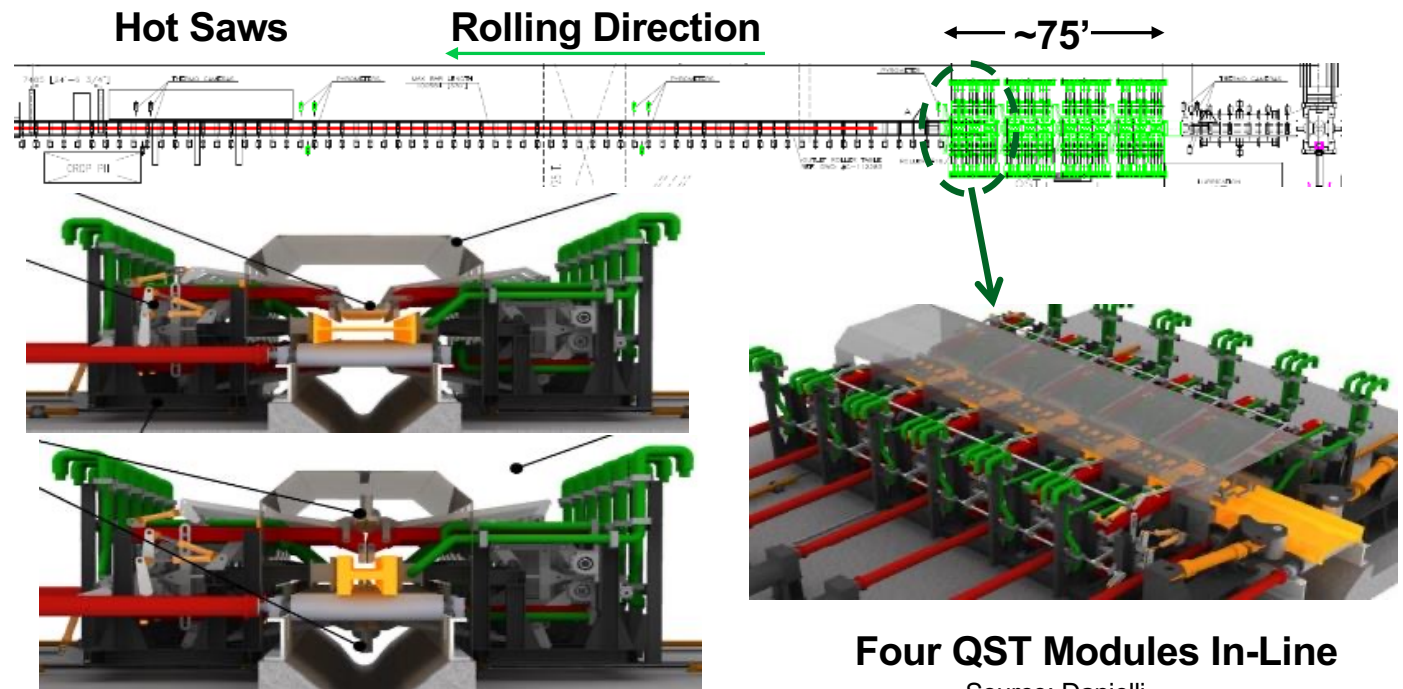
6.1 *Tensile Properties*—The material as represented by the test specimens shall conform to the tensile properties given in Table 2.

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on www.astm.org.



AEOS MANUFACTURING PROCESS

After Hot Rolling, the steel goes through quenching and self-tempering (QST). This is different than Q&T Steel production.

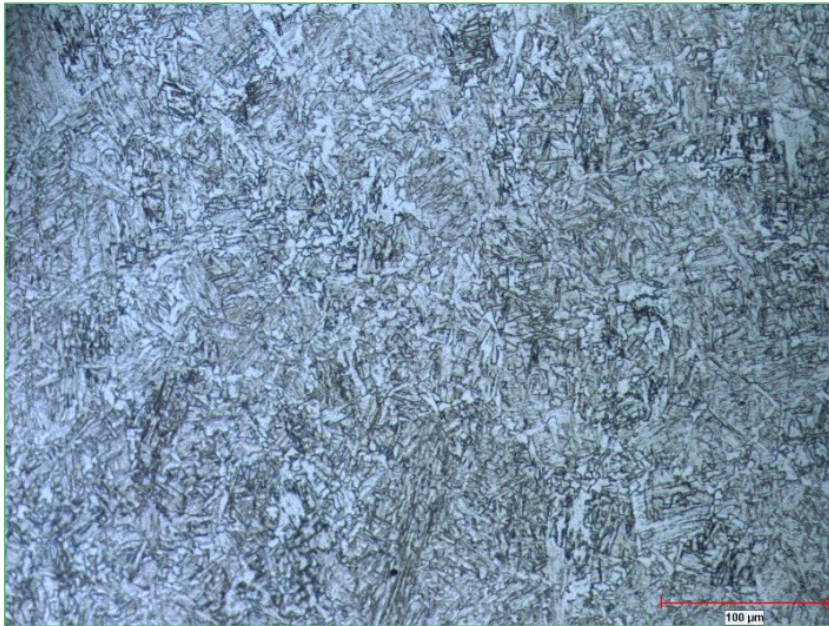


Four QST Modules In-Line

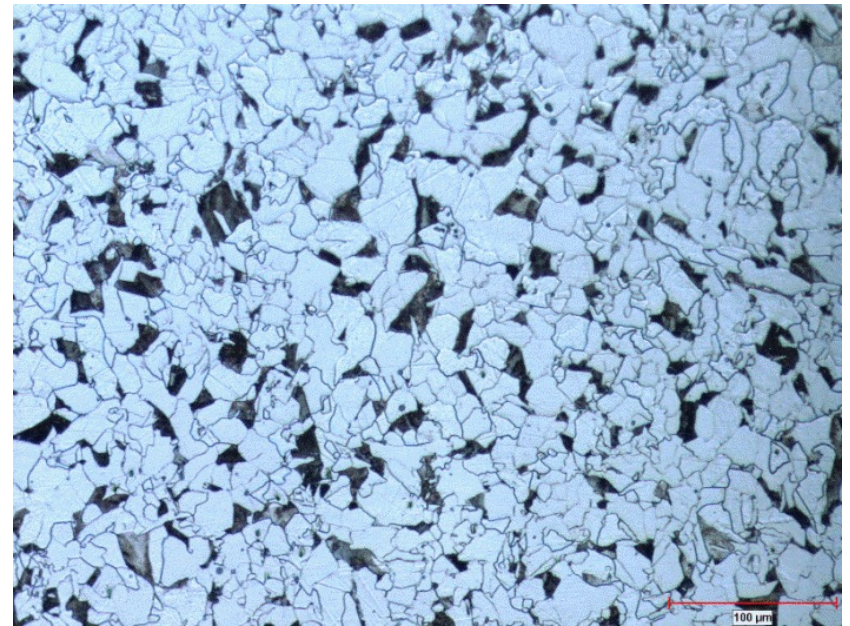
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AEOS QUENCH AND SELF-TEMPER

The Two Distinct Microstructures



Tempered Martensite at surface



Ferrite & Pearlite (similar to A992) at center

AEOS EXAMPLE MTR

Invoice No.		NUCOR-YAMATO STEEL CO. P.O. BOX 1228: BLYTHEVILLE, AR 72316	CERTIFIED MILL TEST REPORT	
Bill of Lading			100% Melted and Manufactured in U.S.A	
Customer No.			All Shapes produced by Nucor-Yamato Steel are cast and rolled to a fully killed and fine grain practice	
Customer P.O.			Date	01/16/2020

ASTM A913/A913M GR65-15
 ASTM A6/A6M-14

Item#	Item Description	QTY	Heat#	Mechanical Properties										STT	Chemical Properties													
				Yield to Tensile Ratio	Yield Strength	Tensile Strength	ELONG	Charpy Impact				Loc	C		Mn	P	S	Si	Cu	Ni	Cr	Mo	V	Cb	CE	Sn	Pcm	Cl
					KSI	KSI		%	Temp	Impact Energy	Temp																	
					MPa	MPa		%	° F	ft· lbf	° F																	
1	W14X550.0 52 ft 8 in W360X818 (16.05 m)	1	505352	0.79 0.81	71 76 491 522	91 93 624 644	29 29	70 21	91 124	86 116	75 102	Fla Cor	1190 643	.07	1.50	.012	.019	.30	.35	.12	.15	.05	.07	.005	.41	.01	.19	

ELONGATION BASED ON 8.00 INCH GAUGE LENGTH
 $P_{cm} = C + Si/30 + Mn/20 + Cu/20 + Ni/60 + Cr/20 + Mo/15 + V/10 + 5B$ (B=Approx .0005)
 Corrosion Index= $26.01(\%Cu) + 3.88(\%Ni) + 1.2(\%Cr) + 1.49(\%Si) + 17.28(\%P) - 7.29(\%Cu)$
 $(\%Ni) - 9.10(\%Ni)(\%P) - 33.39(\%Cu)^2$
 ISO 9001:2015 certified (Registration #0985-07).
 Meets mechanical lab independence requirements of EN10204 type 3.1.
 The Charpy machine striker geometry used by Nucor-Yamato Steel is the 8 mm (0.315") striker (KV₂) per ASTM A370 Section 22.1.2 and ISO 148-1 Section 7.3.

CARBON EQUIVALENT CE= $C + Mn/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15$
 Mercury has not been used in the direct manufacturing of this material.
 This material was produced in accordance with the Nucor-Yamato Steel Quality Manual.

I hereby certify that the contents of this report are accurate and correct. All test results and operations performed by this material manufacturer are in compliance with the requirements of the material specifications, and when designated by the purchaser, meet the applicable specifications.

Doug Lennell
 Chief Metallurgist

State of Arkansas
 County of Mississippi
 Sworn to and subscribed before me
 on 01/16/2020
 My commission expires on 07/17/2023



Low CE and Pcm is maintained through more restrictive chemistry
Note that the STT is unique to AEOS

BENEFITS OF AEOS FABRICATION

Pre-Qualified in AWS D1.1: 2020 Clause 5

Table 5.3 Approved Base Metal Group III

Table 5.4 Filler Metal for Matching Strength –

Example E8018-XX AEOS Grade 65

Table 5.9 Prequalified Preheat and Interpass
Temperature – Category D w/ Low Hydrogen
electrode

Fabricator can develop Welding Procedure
Specification without cost of Performance
Qualification Report (Qualifying by Testing)



BENEFITS OF AEOS FABRICATION

REDUCED PREHEAT REQUIREMENTS

Reduction of preheat requirement can save hours for preparing welds both in the fabrication shop and in the field

Applicable when base metal temperature is above 32°F and H8 electrodes are used

The heat input limitations of AWS D1.1 Clause 7.7 do not apply to AEOS QST W Shapes.

Comparison of Aeos to A992			
Measure	Aeos 50	Aeos 65	A992
Yield strength, ksi	50	65	50
Tensile strength, ksi	65	80	65
Max. yield strength, ksi	65	No Max.	65
Max. yield-to-tensile ratio	0.85	No Max.	0.85
Min. CVN: 40 ft-lbf @ 70° F*	Yes	Yes	No
Min. elongation (8" sample)	18%	15%	18%
Max. carbon equivalent %	0.38	0.43	0.47/0.45**
Weldable without preheat	Yes	Yes	No

*Supplement S30 may be requested on the purchase order for Charpy V-notch testing at the alternate core location for shapes with a flange thickness greater than 1 1/2". CVN impact tests shall be performed according to ASTM A673 to a minimum average absorbed energy for each test of 20 ft-lbf at 70° F unless noted otherwise on the purchase order.

** 0.47% for section with flange thickness greater than 2" (50 mm), 0.45% for all other shapes.

BENEFITS OF AEOS FABRICATION

Preheat Validation

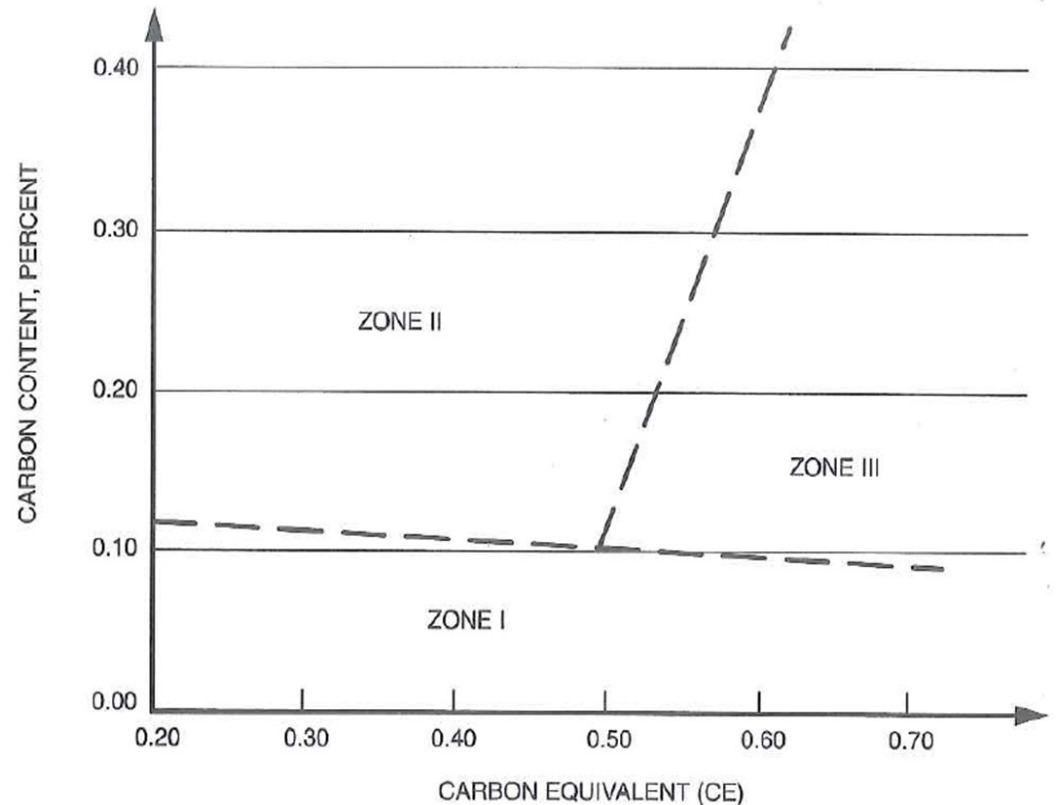
AWS D1.1 Annex B Guideline for Alternative Methods for Determination of Preheat - Figure B.1 Zone Classification of Steels

With AEOS Grade 65 being in Zone I -

Cracking is unlikely unless high hydrogen or high restraint exist

Table B.1 and B.2 can provide assistance in determining minimum preheat.

Chemistry specification is more restrictive for AEOS than A992.



AWS D1.1 Figure B1

OTHER AEOS FABRICATION CONSIDERATIONS

- Saw cutting costs are comparable to A992
- Drilling costs consistent with A992, may need more oil to initiate drilling
- Punching not assessed, not typically used with higher strength steel grades
- Torch cutting costs are consistent with A992
- Heat Straightening & Post Weld Heat Treated have a maximum temperature of 1100°F

The appropriate UT specification for W Shapes is ASTM A898. Two levels of acceptance are available and the appropriate level must be designated in the contract documents.



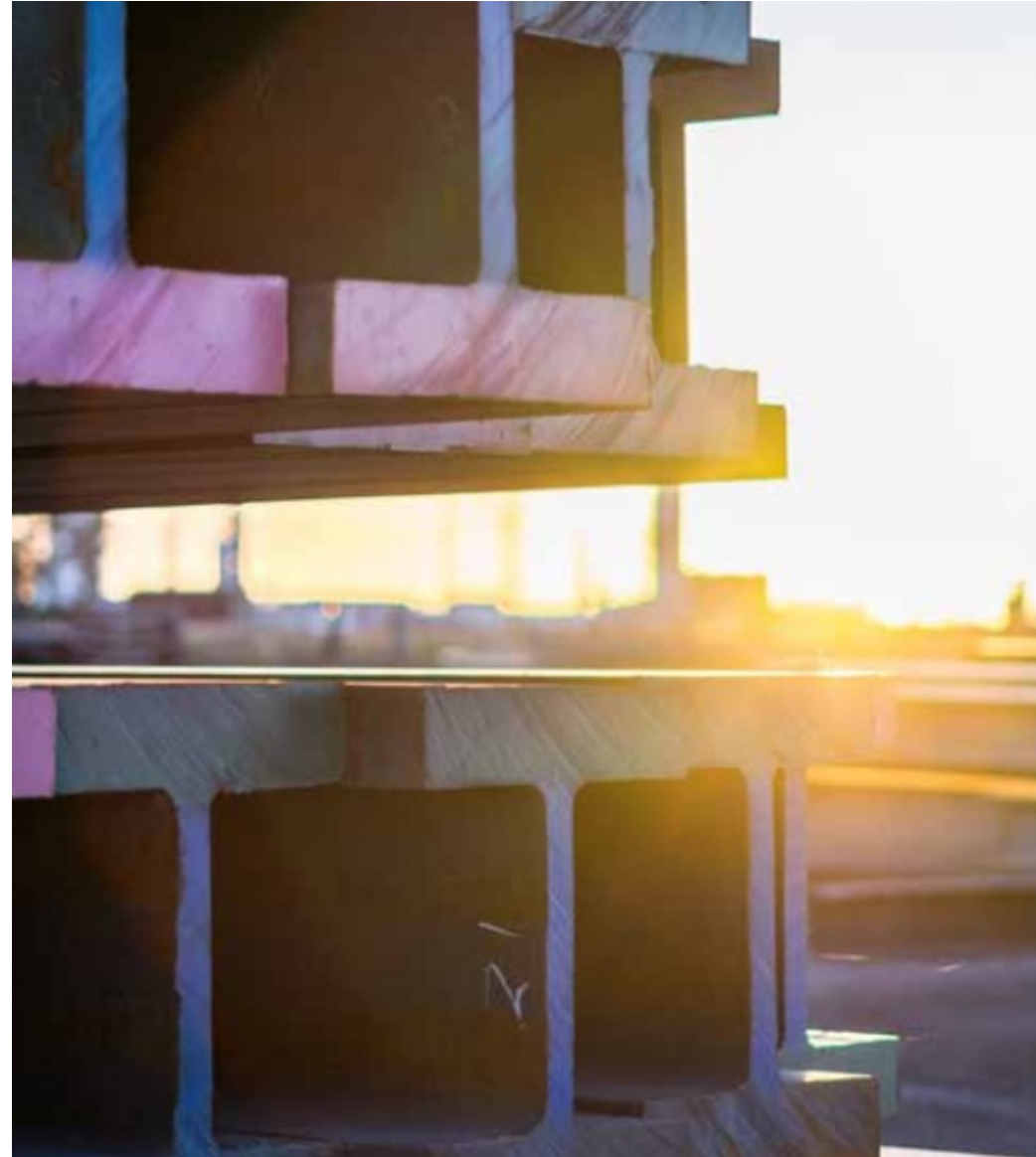
Photo Credit: NASA/Kim Shiflett

AEOS WELDABILITY SUMMARY:

“Your AEOS Steel Welds like Butter”

- St. Louis Fabricator

- AEOS QST is not the same as Q&T
- Prequalified in AWS D1.1
- Lower Preheat than A992
- Uses a higher strength electrode
- Processing costs comparable to A992
- Heat Straightening & PWHT limited to 1100°F



THANK YOU

NUCOR CONSTRUCTION SOLUTIONS

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